

Activity #1

# Anchialine Pond Detective Story

## ● ● ● Class Period One *Anchialine Pond Detective Story*

### Materials & Setup

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- “The Anchialine Pond Detective Story” acetates (master, pp. 11-19)
- Overhead projector and screen

*For each student or group of three to four students*

- Student Page “The Anchialine Pond Detective Worksheet” (pp. 20-25)

*For each student*

- Student Page “Hypothetically Speaking” (pp. 26-28)

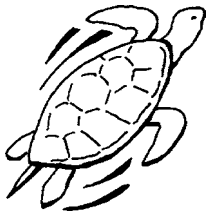
### Instructions

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- 1) Divide the class into groups of three to four students, or have students work individually. Hand out the Student Page “The Anchialine Pond Detective Worksheet.”
- 2) There are eight acetates.
  - Acetate #1 introduces anchialine ponds and the activity.
  - Acetates #2-6 each pose a mystery for students to resolve to by developing hypotheses. Most include the question, a photo, and a series of observations.
  - Acetate #7 is an “Information Interlude” that provides students with background for the next “mystery” acetate.
  - Acetate #8 is another “mystery” acetate that includes a question, a photo, and a series of observations.

Use the acetates as a “script” for this activity. Go through the acetates, one by one, giving student groups time to come up with a hypothesis for each question and write it on their worksheets. You may incorporate class discussion into this activity by asking students to discuss their ideas openly with each other before recording their hypotheses. Before moving on to the next acetate, review the correct answer using the responses and additional information provided in the teacher background for “The Anchialine Pond Detective Story” (pp. 7-10).

- 3) Hand out the Student Page “Hypothetically Speaking” as homework.



### Journal Ideas

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- Do you think it's important to protect the anchialine pools on Maui? Why or why not?
- Write a short story about the adventures of a traveling shrimp.

### Assessment Tools

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- Participation in group work
- Student Page "The Anchialine Pond Detective Worksheet"
- Student Page "Hypothetically Speaking"
- Journal entries

Some teacher-only resources have been omitted from the online document.

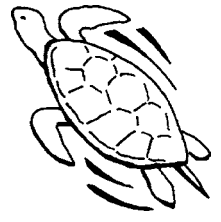
They are available as password-protected files at:

[www.hear.org/hoike/teachermaterials](http://www.hear.org/hoike/teachermaterials)

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# The Anchialine Pond Detective Story

## Acetate #1

### What are Anchialine Ponds?

Here and there in the rough 'a'ā flows that dominate the southwest coastline of Maui between Cape Kīna'u and Cape Hanamanioa, lies a scattering of anchialine ponds. Anchialine ponds are brackish or saltwater pools, a unique habitat found on Maui, O'ahu, and Hawai'i, as well as on other islands and coastal areas in tropical regions around the world.

Anchialine ponds are simple natural systems in which the balance is easily disturbed. For example, people sometimes disrupt the system by dumping aquarium fish in the ponds. The fish eat all the red shrimp, which normally feed on algae. With the shrimp essentially removed from the system, the algae can take over the pond.

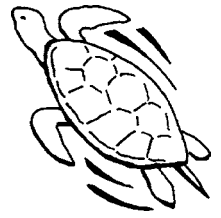


*Anchialine ponds at 'Āhīhi-Kīna'u  
(Photo: Forest Starr and Kim Martz)*

### Mysteries to Solve

Anchialine ponds in Hawai'i are home to several species of tiny shrimp, some of which are found nowhere else in the world and others which have been found in anchialine ponds thousands of miles away.

You will be asked to solve six mysteries linked to these tiny shrimp. You will develop hypotheses to explain these mysteries based on observations made by scientists who have studied these unique ponds and their tiny inhabitants for many years.



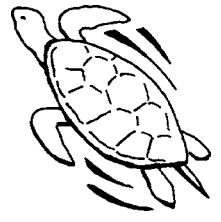
### Mystery #1

The water in the ponds is both fresh water and salt water. Where does this water come from?



*Anchialine pool at Kanaio  
(Photo: Philip Thomas)*

- Observation #1      If you taste the water, it is slightly salty but not as salty as the ocean.
- Observation #2      While the ponds in the photos are near the coast, they are far enough from the ocean that waves do not break into them.
- Observation #3      The water in the ponds rises and falls with the tides along the shoreline.
- Observation #4      If you swim along the lava rock shoreline, you will swim through water that is very blurry and colder than the surrounding ocean water.
- Observation #5      Hawaiians living along the lava shorelines from Cape Kīna‘u, Kanaio and south to Kahikinui were able to dig wells along the coast or explore coastal lava tubes and find water that was slightly salty but good enough to drink. This was the only source of water for many people living along this coastline.



### Acetate #3

## Mystery #2

What makes the water turn red each spring at Wai‘ānapanapa?

Popoalaea, a Hawaiian chiefess from the Hāna area above Wai‘anapanapa, was married to a powerful and arrogant warrior chief named Kakae. Kakae became jealous of her affection for her brother, Pi‘ilani, and threatened to kill the chiefess. Popoalaea fled for her life, along with her faithful companion, Manona.

At the last minute, Manona picked up a small *kāhili*. This feathered standard was a symbol of royalty. They fled toward the sea, travelling in lava tubes and under cover until they reached the ocean at Papaloa, near Hāna.

Popoalaea and Manona found a deep cavern in which they hid during the day, emerging only at night to look for food and a way to escape to another island. A pool of water filled the entrance to the cave, and to enter, the women had to dive into the pool and under a jutting ledge. The cavern opened into a low room where Popoalaea and Manona passed their days silently dangling their feet in the water. Manona would sometimes wave the *kāhili* slowly back and forth to distract her mistress’s thoughts.

Meanwhile Kakae searched madly for his wife. At the village of Honokalani, he heard strange tales of spirits wandering the shore at night. Nearby, he stopped to rest on the rocks just above a pool of water at the entrance to a cave. He noticed the perfect reflection of the cave roof in the still surface of the water. Suddenly he saw something move in the reflection, and recognized it as the *kāhili*.

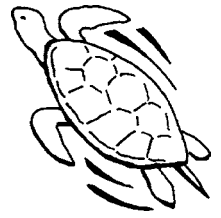
Kakae and his men dove into the cavern and there killed both women by dashing them against the rocks, then throwing their bodies into the pool. To this day, the roof and sides of the cave are dark with the women’s blood. On the nights of Kū, when the moon is in a certain stage, the waters of the pool are said to become red, and there is an eerie light in the cave.

In the spring—the time of year at which the tragedy took place—the stones are said to be a redder hue.

*Adapted from Elspeth P. Sterling, Sites of Maui, Bishop Museum Press, Honolulu, 1998, pp. 125-6.*



*Wai‘ānapanapa cave  
(Photo: Carol Gentz)*



Acetate #4

### Mystery #3

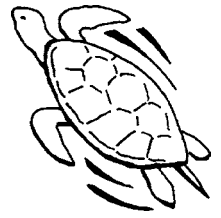
You often see small, red shrimp in the ponds. If all the water goes out of the ponds at low tide, the shrimp disappear. Where do they go?



*Photo: John Hoover, Hawai'i's Sea Creatures, Mutual Publishing*

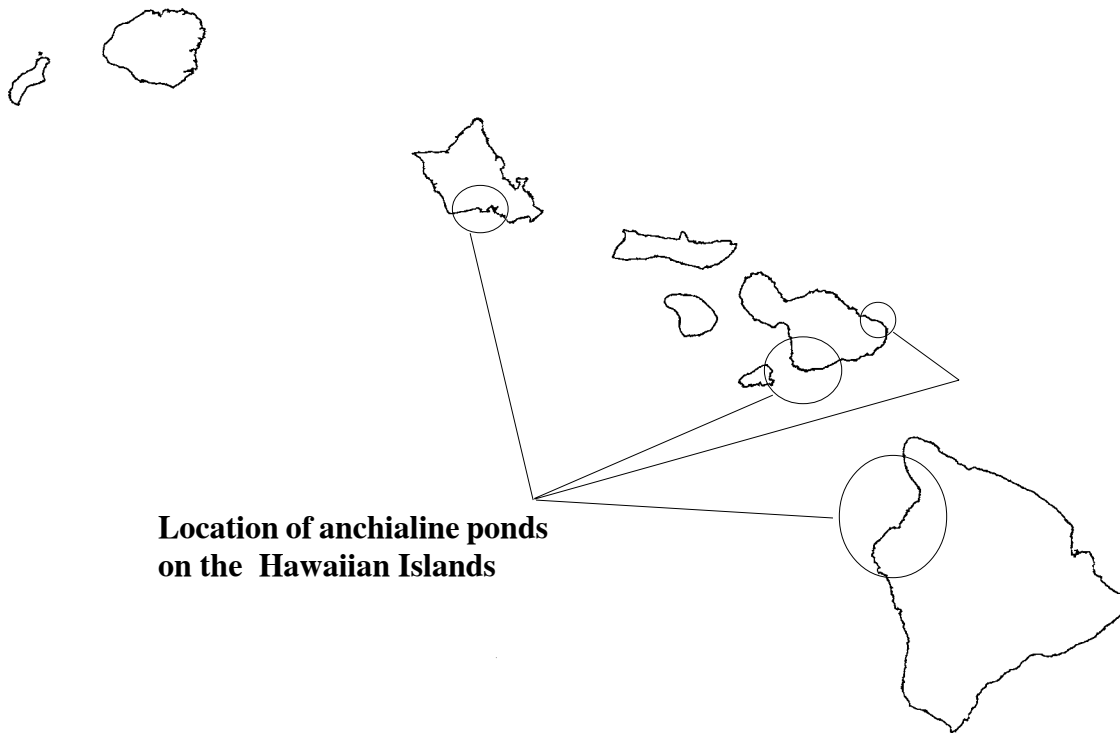
- Observation #1: When the tide starts rising and the water level rises in the ponds, too, the shrimp enter the ponds.
- Observation #2: If you dig a well along the shoreline, you are likely to have some of these shrimp in your well.
- Observation #3: So far, the shrimp found in the ponds in Hawai'i have not been seen in the ocean. But they are small, so it could be the case that they simply have not been discovered in the ocean yet. Most do not exceed 3.0 cm (1.2 in) in body length.



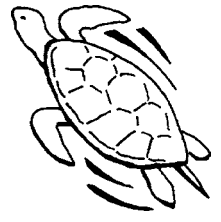


### Mystery #4

The same species of shrimp that live in the Maui ponds also live in similar ponds on the Kona coast of Hawai'i and holes in the ancient (and dry) coral reef that is now the 'Ewa plain of O'ahu. How did the shrimp travel between the islands?



- Observation #1      These shrimp can live in a wide range of salinity levels but need some saltiness in the water.
- Observation #2      Maui and the Big Island have a deep-water channel between them, and even when the sea level was lower during the last ice age about 12,000 years ago, there was still a deep channel.
- Observation #3      In their larval stages, reef fish and corals disperse to other places as part of the "plankton" (tiny organisms that float freely through the ocean).

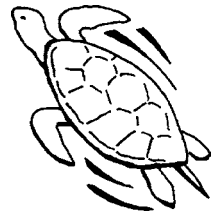


### Mystery #5

The larvae reach the shorelines of the other islands. How do they get into the ponds?



*Anchialine ponds at Cape Hanamanoa  
(Photo: Forest Starr and Kim Martz)*



## Information Interlude

Anchialine ponds are found in coastal areas throughout the tropics. As you can see from the maps in “The Anchialine Pond Detective Story Worksheet,” certain species are found in ponds separated sometimes by thousands of miles of ocean.

Find these examples on the shrimp distribution maps:

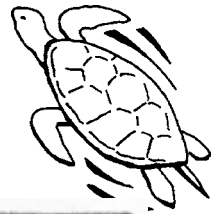
Cp = *Callinectes pholidota*

Found in ponds on Hawaiian Islands, Ellice Islands, and the north end of the Red Sea

Al = *Antecaridina lauensis*

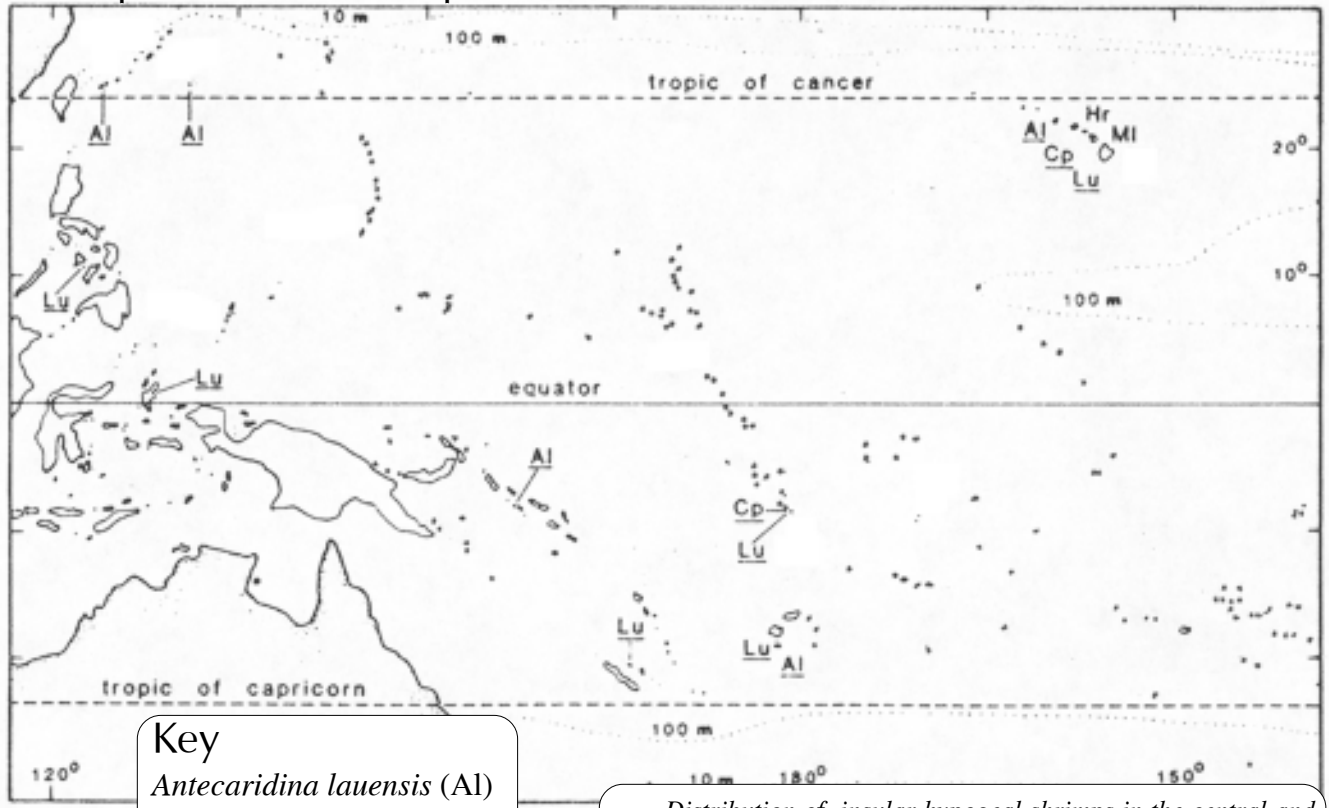
Found in ponds on Hawaiian Islands, Fiji Islands, Mozambique Channel Islands, Solomon Islands, at the south end of the Red Sea, and in Japan

According to widely accepted ideas about isolation and speciation, these widely separated populations should have diverged into separate species because of the limited pool of genetic material and specific local conditions. If these shrimp populations are as separate as they seem, scientists would expect to see more endemic shrimp species and fewer species that were scattered in anchialine ponds around the world.



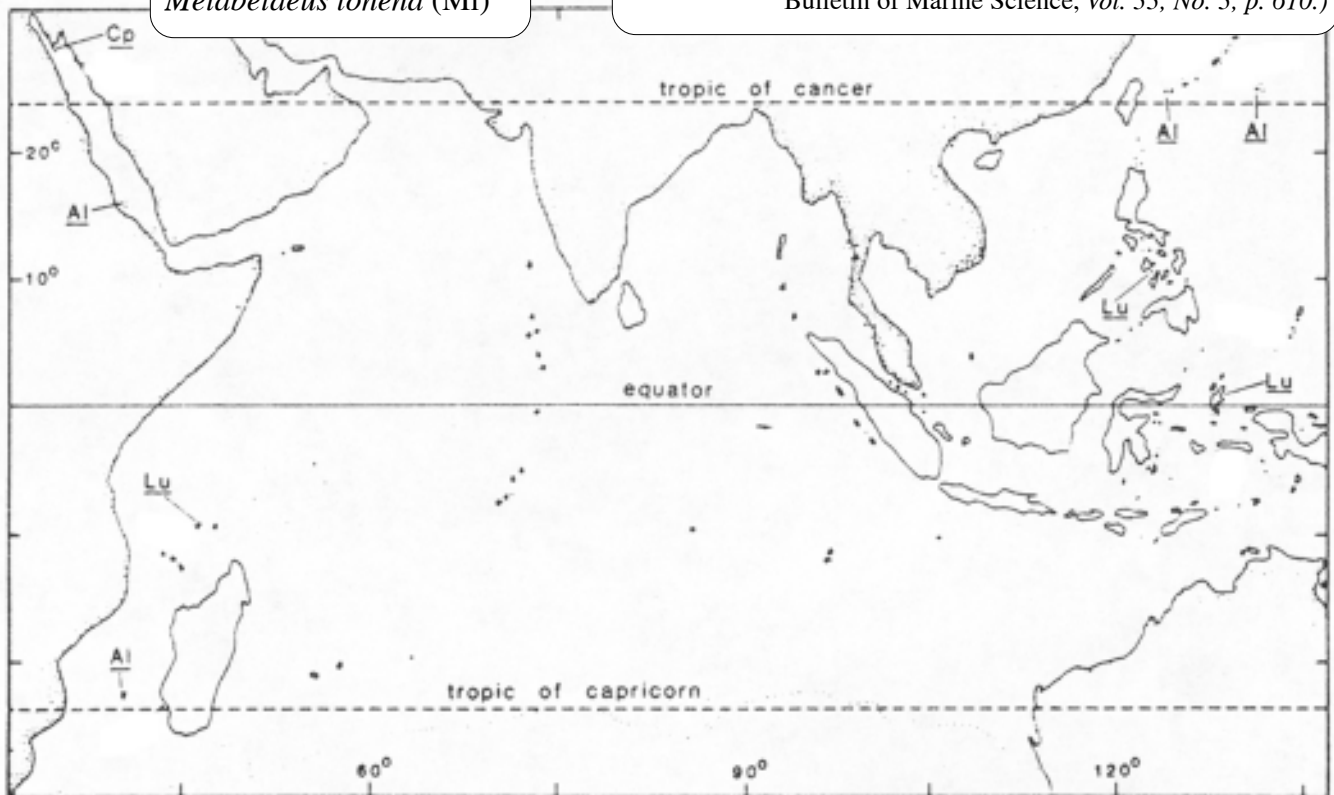
Acetate #8

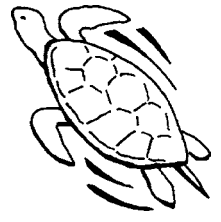
Shrimp Distribution Maps



**Key**  
*Antecaridina lauensis* (Al)  
*Calliasmata pholidota* (Cp)  
*Halocaridina rubra* (Hr)  
*Ligur uveae* (Lu)  
*Metabetaeus lohena* (MI)

*Distribution of insular hypogean shrimps in the central and western Pacific Ocean (above) and western Pacific and Indian Oceans (below) (Adapted from John A. Maciolek, "Distribution and Biology of Indo-Pacific Insular Hypogean Shrimps," Bulletin of Marine Science, Vol. 33, No. 3, p. 610.)*





## Acetate #9

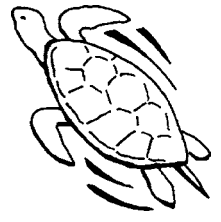
### Mystery #6

Theories about isolation and speciation hold that shrimp species that live thousands of miles apart should have evolved into separate species. What can explain the fact that populations of the same shrimp species are found thousands of miles apart?



Photo: John Hoover, Hawai'i's Sea Creatures, Mutual Publishing

- Observation #1      The shrimp *Antecaridina lauensis* (Al), *Halocaridina rubra* (Hr), and *Metabetaeus lohena* (MI) can live up to 5 years in aquariums. They live longer than other types of small shrimp.
- Observation #2.      All of the small, red shrimp found in the anchialine ponds can tolerate a wide variation in “salinity” (saltiness of the water), but they must have a little bit of seawater in the mix. They can live in pure ocean water.
- Observation #3      All these shrimp need dark, underground crevices. While human beings have mostly seen them in the ponds, the shrimp probably do not need to come into ponds. While *Ligur uveae* (Lu) is found in ponds in other parts of the world, it has never been seen in a pond in Hawai‘i. Here, it has been seen by divers only in underwater caves. While we tend to associate the shrimp with anchialine ponds, it is possible that they do not *need* to live in or on “emergent land” (land that comes out of the water, an island).
- Observation #4      On islands where populations of the shrimp have been found in anchialine ponds, the shrimp sometimes show up in new holes in the ground such as a bomb crater, wells, and quarries, as well as in ponds in recent lava flows. This suggests that they have migrated through underground crevices to enter these new holes, so there is probably an extensive underground population.
- Observation #5      Only two of the many species of small, red shrimp are endemic to an area. Since isolation generally results in the evolution of new species, this seems to indicate that larvae are passively floating in currents between these various areas. But in many places the currents don’t go the right way!

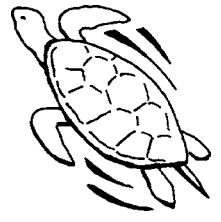


# The Anchialine Pond Detective Worksheet

Solve the following mysteries using the information your teacher will present to you. Like a detective, your job is to piece together observations or clues to arrive at a conclusion.

**Mystery #1:** The water in the ponds is both fresh water and salt water. Where does this water come from?

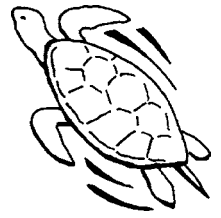
**Mystery #2** What makes the water turn red each spring at Wai‘ānapanapa?



**Mystery #3** You often see small, red shrimp in the anchialine ponds. If all the water goes out of the ponds at low tide, the shrimp disappear. Where do they go?

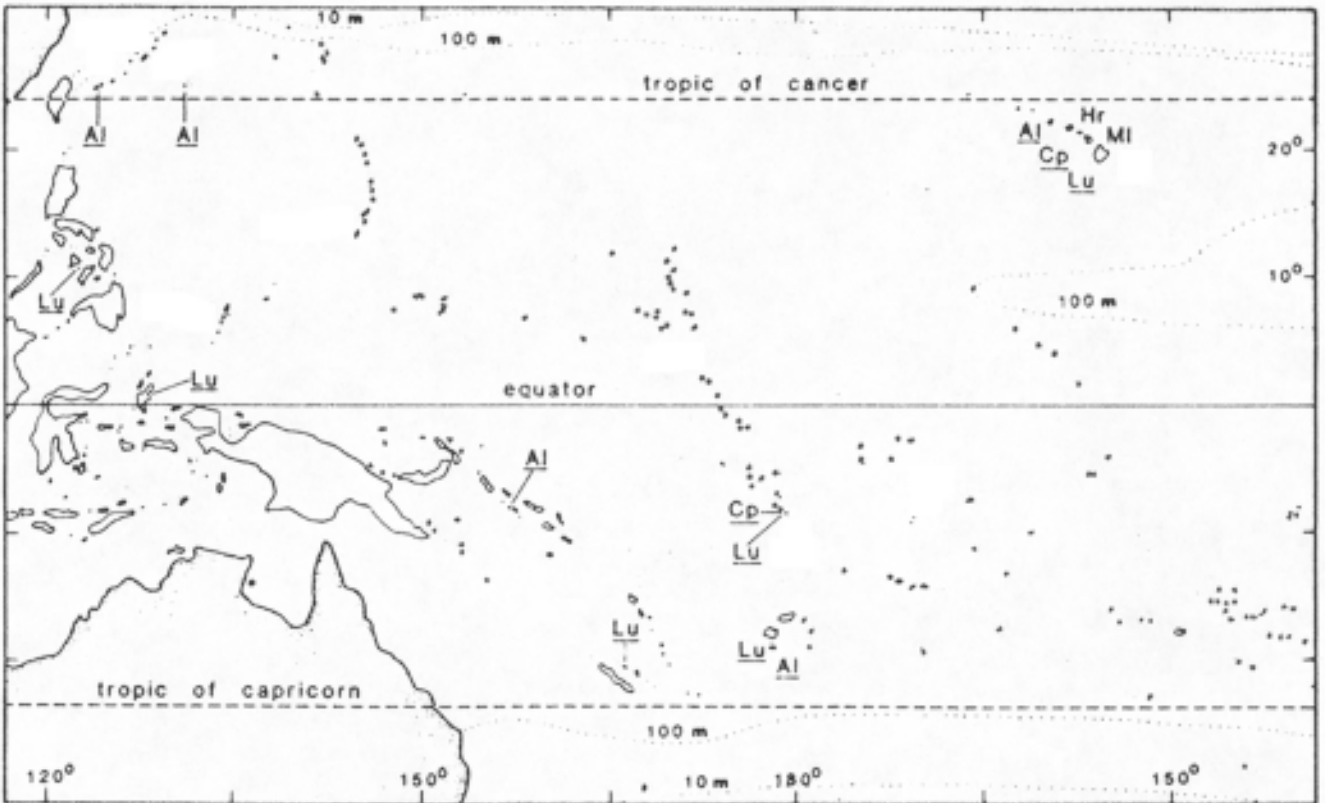
**Mystery #4** The same species of shrimp that live in the Maui ponds also live in similar ponds on the Kona coast of Hawai'i and holes in the ancient (and dry) coral reef that is now the 'Ewa plain of O'ahu. How did the shrimp travel between the islands?

**Mystery #5** The larvae reach the shorelines of the other islands. How do they get into the ponds?



## Information Interlude

### Shrimp Distribution Map: Central and Western Pacific Ocean

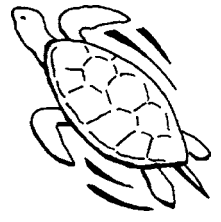


*Distribution of insular hypogeal shrimps in the central and western Pacific Ocean (Adapted from John A. Maciolek, "Distribution and Biology of Indo-Pacific Insular Hypogeal Shrimps," Bulletin of Marine Science, Vol. 33, No. 3, p. 610.)*

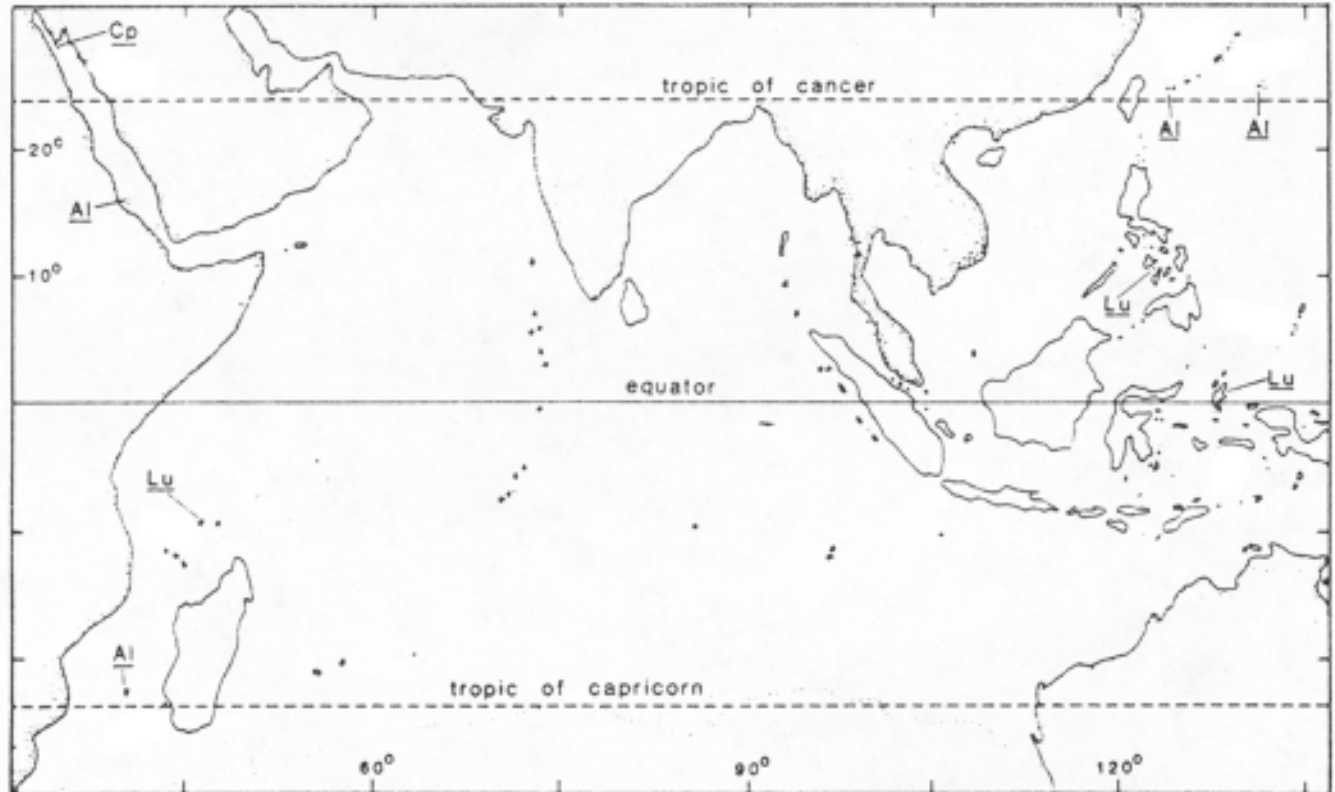
### Key

- Antecaridina lauensis* (Al)
- Calliasmata pholidota* (Cp)
- Halocaridina rubra* (Hr)
- Ligur uveae* (Lu)
- Metabetaeus lohena* (MI)





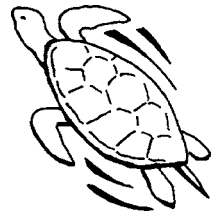
## Shrimp Distribution Map: Western Pacific and Indian Oceans



*Distribution of insular hypogeal shrimps in the western Pacific and Indian Oceans (Adapted from John A. Maciolek, "Distribution and Biology of Indo-Pacific Insular Hypogeal Shrimps," Bulletin of Marine Science, Vol. 33, No. 3, p. 611.)*

### Key

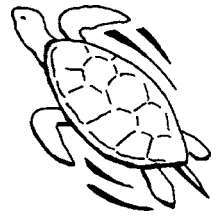
- Antecaridina lauensis* (Al)
- Calliasmata pholidota* (Cp)
- Halocaridina rubra* (Hr)
- Ligur uveae* (Lu)
- Metabetaeus lohena* (Ml)



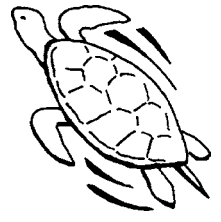
## Distribution of Indo-Pacific Caridean Hypogeal Shrimp Species (the small, red shrimp in anchialine ponds) Found in Hawai‘i

Family, Genus, Species	Locality	Island(s)
<b>Alpheidae</b>		
<i>Metabetaeus lohena</i> (Ml)	Hawaiian Islands	Hawai‘i, Maui
<b>Atyidae</b>		
<i>Antecaridina lauensis</i> (Al)	Fiji Islands	Namuka, Wangava
	Mozambique Channel Is.	Europa
	Red Sea-Dahlak	Entedibir
	Hawaiian Islands	Maui, Hawai‘i
	Daito Islands	Minami
	Ryukyu Islands	Kuro
	Solomon Islands	Uipi
<i>Halocaridina rubra</i> (Hr)	Hawaiian Islands	Hawai‘i, O‘ahu, Maui, Moloka‘i
<b>Hippolytidae</b>		
<i>Calliasmata pholidota</i> (Cp)	Red Sea-Sinai	Ras Muhammad
	Ellice Islands	Funafuti
	Hawaiian Islands	Maui, Hawai‘i
<i>Ligur uveae</i> (Lu)	Molucca Islands	Halmahera
	Loyalty Islands	Uvea/Sayawa
	West Indian Ocean	Aldabra
	Fiji Islands	Vanua Levu, Vanua Vatu, Vatulele
	Ellice Islands	Funafuti
	Philippine Islands	Tiniguiban
	Hawaiian Islands	O‘ahu, Hawai‘i, Maui
<b>Procarididae</b>		
<i>Procaris hawaiiana</i>	Hawaiian Islands	Maui, Hawai‘i

Based on John A. Maciolek, "Distribution and Biology of Indo-Pacific Insular Hypogeal Shrimps,"  
Bulletin of Marine Science, 1983, Vol. 33, No. 3, pp. 606-618.



**Mystery #6** Theories about isolation and speciation hold that shrimp species that live thousands of miles apart should have evolved into separate species. What can explain the fact that populations of the same shrimp species are found thousands of miles apart?



# Hypothetically Speaking

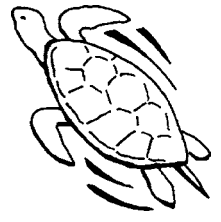
- 1) In 1983 a scientist named Dr. John Maciolek offered a hypothesis to explain the widely scattered populations of the small, red shrimp species found in anchialine ponds. Based on the evidence, he thinks that the shrimps' habitat is much broader than is commonly thought. Instead of occurring only in association with a scattering of anchialine ponds and their porous substrates, Maciolek hypothesizes that "the shrimps could occur in the groundwaters of many . . . islands where they have not yet been found, in shallow reefs and seamounts, and possibly in suitable rock of continental shelves." (John A. Maciolek, "Distribution and Biology of Indo-Pacific Insular Hypogean Shrimps," *Bulletin of Marine Science*, 1983, Vol. 33, No. 3, pp. 606-618.)

In other words, these shrimp could be hiding out in all kinds of submerged nooks and crannies—reducing the distances between what now seem to be separate populations.

Dr. Maciolek goes on to say he thinks the distribution would be restricted by water temperature. There is evidence to suggest that the shrimp do not survive in water colder than 20° C. In the tropics, that generally means that the shrimp could survive in waters no deeper than 100 m (328 ft).

Do you think Dr. Johan Maciolek offers a reasonable hypothesis? Why or why not?





- 4) Assuming that you were unable to look directly for shrimp in underwater rock crevices, how would you study the shrimp themselves to determine whether the shrimp would be physiologically able to live in these underwater habitats? Keep in mind that these underwater habitats would have the consistent salinity of sea water and may be darker or cooler than exposed or near-surface waters depending on their depth.